

Report for 2003TX96B: Spatial and Temporal Characterization of the Radon Distribution in a Region of the Hickory Aquifer in Central Texas: Assessment of Stratigraphy and Groundwater Dynamics on Radon Concentrations

- unclassified:
 - None

Report Follows

I. Activities in chronological order

- Extensive research on best instrument to purchase to measure radon in groundwater led to decision to try to purchase a liquid scintillation detector (LSC). Discovered these are expensive instruments, but we have one on campus, in the Environmental Health and Safety Office (EHSO), that could be upgraded to do radon analyses. The manager of the EHSO agreed to let me upgrade their instrument, but the bid came in at ~\$5,500.00, which was more money than I had/wanted to spend since I also need money for analyses of other chemical constituents in the Hickory groundwater.
- Networked through colleagues and friends, spoke with representatives of companies that sell other radon monitoring instruments and contacted government scientists involved in radiochemical analyses (including people at USGS, TAMU Department of Nuclear Engineering, TAMU Nuclear Science Center, Environmental Chemistry Lab at the Texas Department of Health). This effort led to the fortuitous discovery that a personal friend had two radon monitoring instruments that he wanted to sell. It also provided me with some useful contacts at TAMU and TDH.
- Completed a comprehensive literature search on studies of U and Th radionuclides in groundwater and the aqueous chemistry of U, Th, Ra and Rn. This document already has proven to be a very useful resource.
- Purchased the radon monitoring instruments (Pylon AB-5; details on the instrument provided below) and accessories from my friend. These instruments measure radon in air only, so I purchased a Water Degassing Unit (WG1001) from Pylon designed to be used with the AB-5 instruments. This apparatus allows one to strip radon from a water sample so that the radon concentration can be analyzed with the AB-5. An added benefit of using these instruments is that the water sample can be entirely stripped of radon, and then held for about 30 days while radon grows in as the radium in the groundwater sample decays. The sample is then degassed again, and the concentration of radium in the groundwater can be calculated from the radon concentration in the sample. For reasons discussed below, the ability to measure radium concentrations, in addition to radon concentrations, will greatly enhance what can be learned from this study.
- Calibrated Pylon AB-5 with help from Pylon representative. Pylon normally recommends that their technicians calibrate their instruments. Doing this independently helped save the project some money.
- Studied detailed stratigraphy at my field site, layout of monitoring wells and locations of monitoring zones in the wells, as part of the planning for the field efforts.
- Made preliminary measurements of the ^{222}Rn concentration in Hickory groundwater in four monitoring zones in one of the wells and the ^{226}Ra concentration in groundwater

collected from a house well. This field work familiarized me with what to expect, when I undertake the first sampling effort, in terms of collecting water samples from the monitoring wells, degassing the samples, and analyzing them with the Pylon AB-5.

- I presently am preparing to do the initial field work for the project, which will take place during this spring semester. I am designing the groundwater sampling scheme, i.e. which zones will be sampled and which chemical constituents will be included in the analyses. I also am learning to use field analytical instruments, learning about appropriate sample containers, sampling methods, analytical labs and costs of analyses .

II. Analytical instruments

The Pylon AB-5 uses a photomultiplier tube (PMT) coupled with a Lucas style scintillation cell to count the scintillations (light pulses) produced when alpha particles from decay of radon and its two daughter products strike the zinc sulfide coating on the inside of the cell. The scintillator (zinc sulfide) is insensitive to beta and gamma radiation, temperature and humidity. The lowest activity detectable (LAD) by the cells that I purchased is 0.74 pCi/L (27.4 Bq/m³) (LAD is with a 95% probability of being distinguished from background).



Pylon AB-5



Water Degassing Unit

III. Literature Search

The extensive literature search revealed a variety of approaches to studying U- and Th-decay chain radionuclides in rock and groundwater (including field geochemical studies, lab studies, and analytical and numerical models). The take-home message from the literature is that the occurrence of these radionuclides in groundwater is controlled by the concentration and location of the radionuclides in the rock, the complex water/rock interactions that are a function of the

aqueous chemistry, and of course the hydraulic characteristics of the aquifer and surrounding rock units.

Radon gas is chemically inert but can become mobile if it is “ejected” into the groundwater during decay of its parent radium. Since ^{222}Rn ’s half-life is relatively short, 3.82 days, it does not migrate far from its source before it decays. Hence, the concentration of radon in the groundwater reflects the concentration of radium in the rock that is close enough to the water/rock interface such that radon can escape to the water via alpha recoil. The concentration of radium in the groundwater will reflect the concentration of radium in the rock that is close enough to the water/rock interface such that radium can be dissolved (if conditions are suitable), and/or the concentration of it’s parent, thorium, in the rock that is close enough to the water/rock interface such that radium can escape to the water via alpha recoil. The aqueous chemistry controls whether radium that enters groundwater will stay in solution or sorb to mineral surfaces or colloids.

I keep coming back to aqueous chemistry. It is clear that knowledge of the groundwater chemistry is critical to understanding the dynamics of radium, and therefore to some degree radon, in the aquifer. It also is clear from the literature that radionuclide concentrations and groundwater chemical concentrations rarely can be correlated.

IV. Study Site Stratigraphy, Structure and Hydraulics



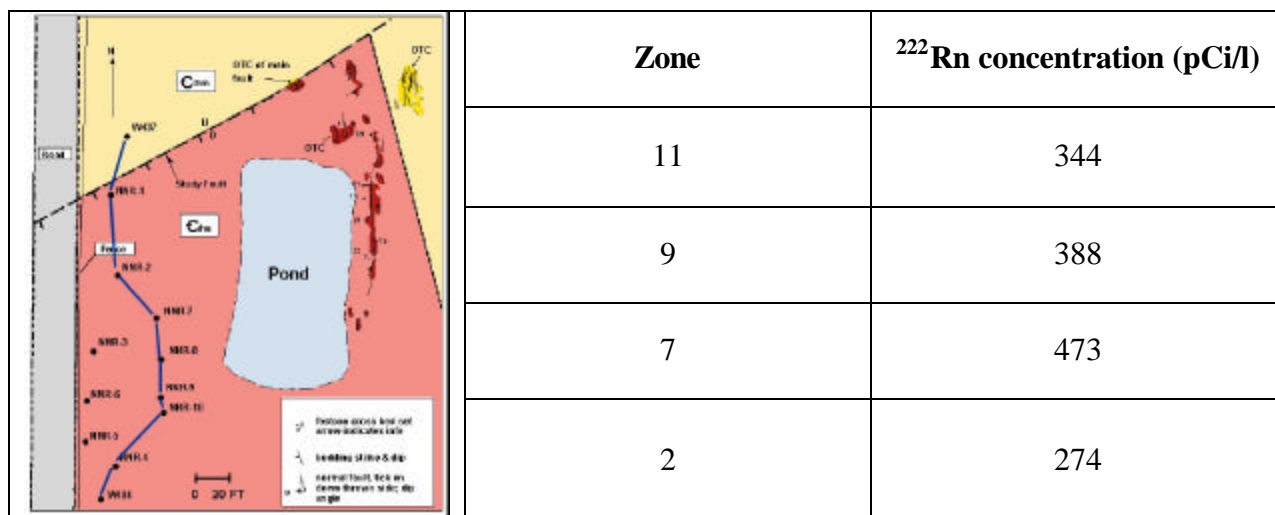
Wilson (2000?) compiled detailed cross sections of the site stratigraphy and geologic structure (faults) and Zhurina (2000) modeled the groundwater flow regime, under the guidance of Professor Brann Johnson. Johnson installed eight Westbay monitoring wells at the site. A total of ninety-four stratigraphic zones are isolated in the wells. Pressures in the zones can be monitored continuously, and groundwater samples can be collected.

The figure at left is a cross section showing the aquifer stratigraphy and five monitoring wells installed in the aquifer. The vertically oriented rectangles represent the location of packers, which are inflated against the borehole wall and impede vertical flow. Many are situated in low permeability clay layers, and therefore isolate more permeable zones in the aquifer.

During the initial field effort, at a minimum all zones in one borehole will be sampled and analyzed for a host of chemical constituents and radon and radium. This data will allow me to characterize the chemistry of the aquifer as it relates to the stratigraphy.

V. Preliminary Measurements

The table below shows the concentrations of ^{222}Rn in Hickory groundwater in four of the monitoring zones in well NNR-4, and the ^{226}Ra concentration in Hickory water collected from a house well near the field area. The site map is provided to show the location of NNR-4. The zones in each well are numbered from the bottom of the well to the top. These preliminary measurements lend confidence to my analytical methods, and suggest that the radon concentration does vary with the stratigraphic units. The detectable radium concentration is not a surprise, since radium has been detected in groundwater from many Hickory water wells.



In conclusion, I believe I have made considerable progress with this research. Though the delay in funding for the project (received the end of July 2003) set back plans for sample collection and analyses, it gave me time to conduct other research critical to the project. Groundwater samples will be collected and analyzed this spring for a host of chemical constituents. The initial sampling effort will identify and quantify the chemical constituents in the water in the various rock layers. This information will be used to plan and undertake a more extensive groundwater sampling and analysis effort.